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EXECUTIVE SUMMARY

THE CHARACTERIZATION OF ASH FROM THE BNPD RADIOACTIVE INCINERATOR

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Incineration of radioactive wastes is one important volume reduction process being utilized at the Bruce Nuclear Power Development Site. The radioactive ash generated as a secondary waste is packaged in galvanized steel containers which are then stored in the Low Level Storage Buildings.

Currently all of Ontario Hydro's low level radioactive waste is retrievably stored. Future waste management strategies include:

(a) storage to 'de minimis' levels of activity at which levels the waste is considered to be non-radioactive, and

(b) permanent disposal of the remaining radioactive waste.

Storage of radioactive ash until the radiological hazard has diminished to acceptable levels would permit it to be disposed of in conventional facilities such as sanitary landfill but there are also concerns that ash could contain other toxic materials such as heavy metals, dioxins and furans besides radioactive elements. In view of this the Materials Chemistry Section has started a program funded by Design and Development Division to:

(a) reexamine fully the chemical, physical and radiochemical composition of radioactive incinerator ash,

job	file	date	report no.
32-140-462	837.812	September 5, 1989	89-186-K

(b) investigate various solidification technologies appropriate for incinerator ash and determine the performance of the resulting waste forms. This would be necessary if the ash contained materials with hazardous lifetimes beyond the extended storage period, and

(c) select the most suitable method for process development.

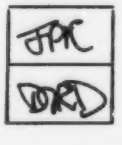
The data contained in this report provides information on the levels of radiotoxic, conventional hazardous constituents in radioactive incinerator ash as well as those parameters which will influence solidification matrix selection.

The data shows that there are, in addition to radioactive contaminants, low concentrations of conventional hazardous materials present in the ash such as heavy metals and organics such as dioxins and furans. The present environmental impact of the hazardous constituents is negligible because active ash is contained in galvanized steel boxes, transported over a very short distance (0.5 km) and retrievably stored in above-ground storage buildings.

Radioactive incinerator ash can be classified as Class A waste based on U.S. NRC waste classification criteria which considers the composition and concentration of radionuclides.

Under U.S. regulations waste conditioning for this waste stream under extended storage or permanent disposal would not require immobilization provided waste characteristics did not change. Since low level waste disposal is not yet practised in Canada there are no present regulations governing conditioning requirements.

However, even though extended storage or disposal safety analyses may indicate that ash can be safely managed without immobilizing, transportation concerns may drive the regulations for conditioning to be more restrictive. Solidification of a dispersible solid also provides another containment barrier for the release of toxic materials in the ash. It is prudent therefore to develop simple solidification techniques for this waste stream even though existing regulations do not demand it.



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THE CHARACTERIZATION OF ASH FROM THE BNPD RADIOACTIVE INCINERATOR

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Bottom ash samples and a sample of baghouse ash from the radioactive incinerator have been extensively analyzed to determine the physical, chemical and radiochemical characteristics of this waste stream. The data indicates that radioactive ash does not require solidification if only current U.S. waste classification criteria covering shallow land burial are considered. However transportation regulations are generally more restrictive and on this basis it may be prudent to develop strategies to immobilize ash. The data documented here will be used in assessing the need and requirements for ash solidification techniques as well as carrying out pathway analyses to estimate radiation dose to the public.

1.0 INTRODUCTION

All radioactive waste, with the exception of irradiated fuel and highly activated reactor components such as pressure tubes, are processed and stored at the Bruce Nuclear Power Development Waste Operations Site. Volume reduction processes consist of an incinerator and a low force compactor. Waste not amenable for processing by these techniques either because of the high metal content or activity level (>0.6 mSv/h) is containerized and placed in one of several storage structures.

The radioactive incinerator is based on batch pyrolysis at a temperature of 500°C in the primary chamber and an afterburner temperature of 950°C. Details of its operation have been described elsewhere/1/. The ash from this process is placed in galvanized steel containers and placed in the Low Level Storage Building.

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A previous program of determining the radiochemical composition of bottom ash concluded/2/ that further packaging of the ash was not warranted based on the low levels of activity expected to prevail at the time the container could no longer be credited with containment. However the characterization of waste from the Pickering Large Scale Fuel Channel Replacement Program showed/3/ that combustible waste contained 3 orders of magnitude more C-14 contamination than similar waste from normal reactor operations/4/. Measurement of the loss on ignition of the ash from one burn using waste generated from the retubing program indicated that the carbon burn-out was incomplete and the ash contained C-14 contamination/5/.

Storage of radioactive ash until the radiological hazard has diminished to acceptable levels would permit it to be disposed of in conventional facilities such as sanitary landfill but there are also concerns that ash could contain other toxic materials such as heavy metals, dioxins and furans besides radioactive elements. In view of this the Materials Chemistry Section has started a program funded by Design and Development Division to:

(a) reexamine fully the chemical, physical and radiochemical composition of radioactive incinerator ash,

(b) investigate various solidification technologies appropriate for incinerator ash and determine the performance of the resulting waste forms,

(c) select the most suitable method for process development.

This report presents data on the physical, chemical and radiochemical composition of representative samples of radioactive ash and discusses the results in terms of solidification requirements.

2.0 EXPERIMENTAL

Over a 6 week period, in May/June 1988, 20 consecutive burns were carried out averaging one complete burn (15 m^3) every 2 days. At the end of each burn, which generated approximately 250 L of bottom ash a 1 L sample was removed from the ash container. Following the 6 week period, a 1 L sample of baghouse ash was removed and this represented the baghouse ash generated (300 L) from the previous 6 week incineration campaign.

The waste incinerated during this period was thought to have been exclusively from Pickering Units 1 and 2. However the presence of Cr-51 in the ash, a short lived isotope, can only be explained on the basis that the waste in fact was a mixture of PNGS Unit 1/2 waste and some normal operating waste.

2.1 Particle Size Distribution

A weighed amount of ash was passed through a number of sieves of increasing mesh size and the weight of ash held up in each sieve was determined.

2.2 Bulk Density

An empty ash sample container was weighed and its volume calibrated using water level in the container. The weight of ash in each container was subsequently determined as well as the level of ash in the container. Using the level/volume calibration for water, the volume of ash and its density in each container were measured without excessive handling of the ash.

2.3 Water Capacity

This test was based on a modification of ASTM D/483-60 "Oil Absorption of Pigments by Gardner-Coleman Method". It has been used previously to determine the capacity of solid absorbents for organic liquids/7,8/, and consists of measuring the amount of water required to be added to a weighed amount of ash until the mixture becomes moist to the extent that it smears the container walls.

2.4 Elemental Composition

X-ray fluorescence and neutron activation techniques were used to determine the elemental composition of the ash. Loss on ignition at 800^{o}C provided information on the carbon content of the ash.

2.5 Dioxin and Furan Analysis

Radioactive ash samples from three consecutive burns were combined to give a single active ash sample for the determination of toxic organics in active ash. Four such composites were prepared, designated as A1 to A4. One baghouse ash sample was also included. 10 g of ash from the samples were extracted using acetone/hexane (1:1) in a Soxhlet extractor for 24 hours in the RML. The extracts which were not radioactive, were then sent to Mann Testing Laboratories for analysis by GC/MS.

3.0 RESULTS AND DISCUSSION

3.1 Waste Feed

Previous characterization studies of incinerable waste/3,4,/ suggested the following average composition of feed to the incinerator.

TABLE 1

INCINERATOR WASTE FEED COMPOSITION

	Routine Operations	Retubing Ops.
Paper	40%	49% (35%)
Plastics		
-PE	33%	18% (34%)
-PVC	4%	13%
-Other	2%	2%
Rubber	5%	8% (15%)
Cotton	9%	5% (13%)
Other	7%	6% (20%)

The "other" plastics category refers to polycarbonate and Tygon, whereas the "other" class of materials consisted of items such as glass, wood, fiberglass insulation and metallic pieces. The numbers in parentheses are the standard deviations calculated for each category and clearly demonstrate the variability of the feed stream. An investigation carried out on feed to a rotary kiln incinerator at a U.S. DOE low level waste facility showed similar characteristics/6/ with respect to the paper (40%), polyethylene (23%) and PVC (8%) content.

3.2 Particle Size Distribution

The bottom ash samples from the radioactive incinerator were beige in color and were quite varied in particle size. Some ash samples contained large clinkers (fused ash), metal pieces and unburnt wood. Table 2 summarizes the particle size distribution of the ash samples. In a previous examination of radioactive ash, in 1983 /2/, there was no mention of any unburnt wood suggesting a more complete incineration process.

Two of the sieved subsamples, namely 88-64S1, 88-74S1 were further sieved. The results which are assumed to be representative of the other samples are compared in Table 3 with the particle size distribution found for baghouse ash. Baghouse ash is a much finer more homogenous solid than bottom ash. These observations are in general agreement with particle size determination carried out on ash from the CRNL incinerator/7/ which indicated that 75% by weight of the ash particles were smaller than 12 mm. Solidification of ash will need to consider the occupational hazards associated with handling such fine materials.

TABLE 2

% COMPOSITION AS A FUNCTION OF SIZE (ASH FROM RADIOACTIVE INCINERATOR)

SAMPLE #	ACTIVTY (cpm) x1000	WT (g)	DENSITY (g/mL)	DISTRIBUTION BY WEIGHT SIEVE 1 <2.36mm	SIEVE 2 2.36mm<x<4.75mm	SIEVE 3 4.75mm<x<9.5mm	SIEVE 4 >9.5mm	% DISTRIBUTION SIEVE 1 <2.36mm	SIEVE 2 2.36mm<x<4.75mm	SIEVE 3 4.75mm<x<9.5mm	SIEVE 4 >9.5mm
88-63	30	228.0	0.66	62.1	24.7	39.5	102.1	27	11	17	45
88-64	200	411.5	0.63-0.74	108.6	40.7	72.5	189.3	26	10	18	46
88-68	20	606.0	0.81	203.4	61.4	91.5	249.4	34	10	15	41
88-69	30	502.8	0.53	180.3	43.3	66.0	212.8	36	9	13	42
88-70	60	449.1	0.68-0.87	188.8	50.9	77.1	132.6	42	11	17	30
88-71	10	35.0	0.34	13.3	6.0	6.2	8.8	38	17	18	25
88-72	30	326.0	0.44	52.3	19.4	33.2	220.0	16	6	10	67
88-73	8	184.9	0.37	87.5	23.9	29.9	43.8	47	13	16	24
88-74	30	573.4	0.72-0.87	169.5	42.8	63.0	298.4	30	7	11	52
88-75	20	462.5	0.72	201.1	38.0	49.1	174.5	43	8	11	38
88-76	10	274.5	0.55	106.9	32.1	42.7	92.5	39	12	16	34
88-77	20	484.7	1.14	55.3	26.7	48.0	354.7	11	6	10	73
88-78	30	107.2	1.08	26.5	8.2	9.0	64.1	25	8	8	60
88-79	20	194.9	0.56	55.8	18.6	31.4	89.4	29	10	16	46
88-80	40	183.7	0.82	21.0	5.5	17.3	138.8	11	3	9	76
88-81	10	712.5	0.84	133.0	55.4	93.6	431.2	19	8	13	61
88-82	60	512.2	0.79	138.4	40.4	56.2	277.2	27	8	11	54
88-83	30	608.4	0.60-0.69	24.8	11.8	28.2	543.2	4	2	5	89
88-84	30	578.4	0.61	163.2	52.1	109.2	252.7	28	9	19	44
880509	20	415.4		10.0	7.2	18.0	380.7	2	2	4	92
880510	8	508.1		6.8	2.8	15.7	482.6	1	1	3	95
BAGHOUSE	8		0.25-0.42								
						MEAN		26	8	12	54
						STD DEV		13	4	5	21

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By comparison, non active bottom ash appears to be more like the baghouse ash from the active incinerator than the active bottom ash and may be indicative of a more complete carbon burn out in the non active incinerators. Approximately 70% by weight of the non-active ash was smaller than 2.4 mm.

TABLE 3

SIZE DISTRIBUTION OF RADIOACTIVE INCINERATOR ASH

		WT DISTRIBUTION (%)					
		<0.1mm	0.1-0.8mm	0.8-2.4mm	2.4-4.7mm	4.7-9.5mm	>9.5mm
BOTTOM ASH	MEAN	3	14	9	8	12	54
	STD DEV	1	2	1	4	5	21
BAGHOUSE ASH		10	80	10	-	-	-

3.3 Bulk Density and Water Absorption Capacity

The bulk density of active bottom ash was determined to be 0.68 ±0.27 g/mL. In contrast, the bulk density of baghouse ash and ash from the non-active incinerators was 0.34 ± 0.08 g/mL and 0.29 ± 0.11 g/mL, respectively.

The amount of water that the ash can absorb was determined to assess the workability of mixtures of ash and water for solidification process development. The data indicates that the baghouse ash although finer and of greater surface area than bottom ash absorbs less water.

TABLE 4

WATER ABSORPTION CAPACITY (mL/g) OF RADIOACTIVE ASH

	Particle Size	
	<2.4mm	2.4mm-4.7mm
BOTTOM ASH	0.54 (0.05)	0.37 (0.03)
BAGHOUSE ASH	0.36 (0.03)	-

Notes:
- A 1% by weight solution of active bottom ash in water was found to have a pH of 9-10.4.
- Numbers in parentheses denote the standard deviation in duplicate measurements.

3.4 Elemental Composition

Table 5 summarizes the elemental composition data obtained by X-ray fluorescence and neutron activation analysis. Oxygen, and nitrogen are not measured by either of these techniques and therefore are not accounted for in Table 5, although most of the elements reported in the table will be present in the ash as the respective oxide and to some extent as the silicate, sulfate, nitrate and chloride. The major elements are carbon calcium, iron, zinc, silicon and aluminum with smaller amounts of copper, lead and titanium.

The loss on ignition of the baghouse ash samples was significantly and consistently higher (>45%) (Table 7) than that from active bottom ash (<15%). Sequential heating of samples of baghouse ash in an air stream showed (Table 6) that the bulk of the weight loss occurs at 400°C and at 1000°C but the bulk of the volume change occurs only at 1000°C. As this large volume change occurs, a heavy yellow deposit formed on the cool sections of the combustion tube. Since the temperature in the afterburner is below 1000°C, this deposit was not analyzed.

TABLE 5

ELEMENTAL COMPOSITION (mg/g) OF INCINERATOR BOTTOM ASH

	MAXIMUM	MINIMUM	MEAN	STD. DEV
C[a]	200	46	113	45
Ca	130	10	55	30
Si	120	0	36	42
Cu	120	0	23	31
Zn	110	3	41	30
Al	105	0	33	34
Fe	100	0	45	30
Pb	90	0	13	21
Ti	70	1	16	18
Cr	40	0	7	9
Mg	36	0	8	13
Mn	21	0	4	5
Ba	20	0	3	5
Na	17	0	6	7
Cl	14	0	4	5
S	10	0	2	3
K	10	0	3	3
P	8	0	1	2
Ni	8	0	2	2
Sb	5	0	1	1
Sr	4	0	1	1
Sn	2	0	0	1
Mo	2	0	0	1

(a) measured by loss on ignition.

TABLE 6

WEIGHT LOSS AT VARIOUS TEMPERATURES FOR BAGHOUSE ASH

TEMPERATURE (°C)	CUMULATIVE WT. LOSS	VOLUME REDUCTION
150 (2h)	5%	0%
400 (2h)	30%	0%
650 (1h)	34%	15%
1000 (20min)	53%	95%

A statistical presentation of the chemical composition of baghouse ash cannot be made because only one sample was obtained representing a one month incineration campaign. The baghouse ash composition is given in Table 7 below. In addition, smaller quantities (<4mg/g) of antimony, tin, aluminum, cadmium, manganese and copper were detected in the ash.

TABLE 7

ELEMENTAL COMPOSITION (mg/g) OF INCINERATOR BAGHOUSE ASH

ELEMENT	C[a]	Cl	S	Na	Zn	P	Si	Ca	Fe
CONCN.	480	110	76	48	51	46	9	4	4

(a) measured by loss on ignition.

Ash obtained from the two BNPD inactive incinerators was also extensively analyzed by Analytical Services for the Environmental Protection Department of CPSD and the data has been reported in Reference 8. The major constituents of this ash are tabulated in Table 8 and show significant differences in the composition of this ash relative to active ash. The heavy metal content of active ash particularly lead, zinc, chromium and copper are significantly greater than in non-active ash while the chlorine content of this ash is greater than active ash. On the assumption that the waste feed composition to the inactive and active incinerators is similar and furthermore the combustion conditions in the two incinerators are similar, it is possible that the heavy metal content of inactive ash is lower as a consequence of the greater volatility of the heavy metal chlorides relative to the corresponding oxides/9/.

TABLE 8

ELEMENTAL COMPOSITION OF ASH FROM NON ACTIVE INCINERATORS (mg/g)

ELEMENT	C[a]	Al	Si	Ca	Fe	Ti	Cl	SO_4^{2-}	Na	Mg	K	Zn
CONCN.	170	145	171	44	30	35	19	20	16	14	10	5
STD.DEV.	93	21	21	19	20	5	15	11	10	2	4	2

(a) measured by loss on ignition

3.5 Radiochemical Composition

The results of radionuclide analysis of both bottom ash and baghouse ash from the radioactive incinerator are summarized in Table 9. The total activity of the bottom ash is roughly equal to the activity of baghouse ash, but whereas the activity of bottom ash is made up of Co-60(28%), La-140(16%), Zr/Nb-95 (16%) Cs-137/134 (13%) and other isotopes, the activity of baghouse ash is predominantly due to Cs-137/134 (89%) reflecting the greater volatility of these isotopes.

TABLE 9

RADIONUCLIDE CONCENTRATION (Bq/g) IN INCINERATOR ASH FROM BOTH RETUBING AND NORMAL REACTOR OPERATIONS

	$T_{1/2}$	BOTTOM ASH MEAN	BOTTOM ASH STD DEV	BAGHOUSE ASH
Total Act.		2127	1321	2953
Co-60	5.3a	599	533	89
La-140	12.8d	333	396	n.d
Cs-137	30.2a	255	207	2467
Nb-95	35d	229	359	6
Cr-51	27.7d	141	385	n.d
Zr-95	64d	111	170	2
Ce-144	284.4d	107	207	n.d
Sr-90	28.1a	n.m	n.m,	n.m
Ru-106	372.6d	74	115	33
C-14	5730a	59	59	28
Sb-125	2.8a	48	37	148
Cs-134	2.1a	19	15	157
Sn-113	115d	11	44	4
Fe-59	44.5d	11	19	n.d
Ru-103	39.2d	7	22	n.d
Eu-154	8.5a	7	7	n.d
Mn-54	312d	7	7	4
Ce-141	32.5d	7	15	n.d
Sb-124	60d	4	4	6
Zn-65	244d	4	4	10
Am-241	432a	4	4	n.d

n.d - not detected

The presence of a significant quantity of Cr-51 in the ash approximately 5 years after the shutdown of Unit 1 and 2 is only consistent with operating reactor waste mixed with the waste from Pickering 1 and 2, generally labelled as retubing waste.

Data from an earlier examination of ash generated by the incineration of waste from the Pickering Retubing Program is summarized in Table 10/3/. It shows that the total activity of bottom ash from waste generated early on in the retubing project is a factor of 3 greater than that generated later on in the recommissioning of the Units (ignoring the presence of waste from operating units).

The largest contributor to the activity in the retubing waste ash was C-14 followed by Co-60. The more recent analyses however show the reverse and reflect the success of the C-14 decontamination efforts as well as the fact that with the reactor retubed the source of the C-14, namely the annulus gas system, was effectively contained. However although the C-14 content in the ash has decreased signigicantly, it is still considerably higher (59 Bq/g) than the C-14 content of ash produced by the incineration of waste from normal reactor operation (3-10 Bq/g), calculated by assuming all of the C-14 in the waste stays in the ash/4/. This confirms the origin of the ash as having come from Pickering 1/2 waste.

Characterization of the C-14 particulate has shown/10/ it to be a polymeric carbon - nitrogen species which is quite stable at high temperatures. Furthermore it is possible that high temperature decomposition of this C-14 rich particulate in the presence of metallic materials in the incinerator results in the formation of stable metal carbide species/11/. The consequence of this is that the technique for measuring C-14 in ash by thermal decomposition may underestimate the actual value. The variance is not expected to be more than 20% but the pathway analysis for estimating C-14 dose rates will need to consider the sensitivity of the dose rate to the C-14 data before a more elaborate analytical technique is developed.

TABLE 10

RADIONUCLIDE CONCENTRATION (Bq/g) IN INCINERATOR ASH FROM RETUBING WASTE

	BOTTOM ASH		BAGHOUSE ASH	
	MEAN	STD DEV	MEAN	STD DEV
Total Act.	6422	3435	966	260
C-14	4810	2511	12	4
Co-60	1042	804	96	21
Sb-125	121	29	78	27
Cs-134	11	2	88	23
Cs-137	74	13	544	152
Nb-95	93	29	16	5
Sr-90	86	0	n.m	-
Cr-51	15	2	5	4
Mn-54	21	18	3	1
Fe-59	3	0	1	0
Zn-65	3	2	15	2
Zr-95	50	17	8	4
Ru-103	10	0.4	13	7
Ru-106	40	2	67	5
Sn-113	1	0.4	6	3
Sb-124	1	0.4	4	0
Ce-141	6	2	1	1
Ce-144	35	3	7	1

n.m - not measured

There was evidence for the presence of Am-241 in all the active bottom ash samples. Because this isotope has a single gamma peak at the low energy end of the spectrum (59.1 keV) which for these samples is normally very noisy, the assignment to Am-241 is uncertain. In a previous report/3/ we found that the ratio of Am-241 to total alpha contamination in processable waste was 0.3. This ratio cannot be used to estimate the alpha activity in ash from the Am-241 ratio because the alpha particulates will have different volatilities under incinerator conditions. Consequently Analytical Services Section is developing a protocol to prepare samples for alpha spectrometry and unambiguously determine the total transuranic content of bottom ash. This information will be reported separately.

Table 11 compares the activity in radioactive bottom ash (mean plus one standard deviation) with the 10 CFR 61 waste classification/12/. A bulk density of 700 kg/m^3 was assumed in the conversion of Bq/g to Bq/m^3. Clearly, even with the elevated C-14 values in ash from retubing waste, the ash generated by the radioactive incinerator is well below the limits set by the U.S. NRC for Class A radioactive waste.

Radionuclide characterization of ash in 1983/2/, generated from normal routine reactor operating waste, gave a maximum Co-60 and Cs-137 activity of 3.1×10^{8} and 4.1×10^{8} Bq/m^3 respectively. These values determined over six years ago are very similar to the ones found in these recent analyses. It is reasonable therefore to assume that the radionuclide data in Table 11 are representative of the ash characteristics and will prevail until a major change in waste feed characteristics occurs.

TABLE 11

ACTIVITY LEVEL(Bq/m^3) OF BOTTOM ASH COMPARED WITH U.S. WASTE CLASSIFICATION

RADIONUCLIDE	BOTTOM ASH THIS WORK	BOTTOM ASH RETUBING	10CFR61 CLASS A
C-14	8.3×10^{7}	5.1×10^{9}	3.0×10^{11}
Sr-90	n.m	6.0×10^{7}	1.5×10^{9}
Co-60	7.9×10^{8}	1.3×10^{9}	2.6×10^{13}
Cs-137	3.2×10^{8}	6.1×10^{7}	3.7×10^{13}
Alpha emitting TRU nuclides with $T_{1/2}$>5yrs	n.a.	$0.1^{(a)(b)}$	$100^{(a)}$

(a) Units are nCi/g
(b) Calculated from reference 3
n.a. - not yet available

3.6 Toxic Chemicals Content of Ash

Following an extended storage period, the radioactivity of the ash may decay to levels at which the waste can be reclassified as non active. The chemical hazards associated with the ash will then be of interest. Five samples of ash from the radioactive incinerator were processed to extract Group A and B contaminants. Group A consisted of chlorinated aromatic hydrocarbons such as dioxins, furans, chlorobenzenes, chlorophenols and polychlorinated biphenyls whereas the contaminants in Group B were polycyclic aromatic hydrocarbons. Table 12 below, summarizes the results for both active and inactive ash.

TABLE 12

ORGANIC CONTAMINANTS(ng/g) IN ACTIVE AND INACTIVE ASH

SAMPLE	DIOXINS	FURANS	Cl-BENZENES	Cl-PHENOLS	PCBs	PAHs
A1	66	202	7220	<200	<200	15100
A2	9	26	1320	<200	<200	140
A3	6	36	8540	<200	<5000	890
A4	19	67	1150	<200	<200	14400
BAGHOUSE	26	53	26000	<200	<1000	100
IA1	78	153	80	1700	<200	1410
IA2	20	81	530	<200	<200	70
IA3	3.2	10	140	<200	<200	100
IA4	0.7	1.9	<60	<200	<200	150
IA5	16	36	10	290	<200	30
IA6	18	33	20	<200	<200	0
IA7	96	190	250	1340	<200	1040

Although only the total chlorinated dioxin and furan concentrations are quoted here, the GC/MS technique analyses for individual compounds and associated isomers. The levels of these contaminants are similar in both active and non-active ash and are low enough not to present either an occupational or an environmental concern for inactive ash/14/ that is presently placed in sanitary landfill at BNPD. It should be noted that waste from Pickering Units 1 and 2 had a higher percentage of PVC plastic and rubber (Table 1) than waste from routine operations. The resulting off gas and ash quality is therefore expected to represent the worst case situation with respect to toxic constituents. Based on present environmental standards concerning organic contaminants, the active ash at the end of its radiotoxic lifetime would not be classified as a hazardous material.

4.0 CONCLUSIONS

Characterization of radioactive incinerator ash has quantified the levels of radiotoxic as well as conventional hazardous constituents and those parameters which will influence solidification matrix selection.

The present environmental impact of the hazardous constituents is negligible because active ash is contained in galvanized steel boxes, transported over very short distance (0.5 km) and retrievably stored in above ground storage buildings.

Radioactive incinerator ash can be classified as Class A waste based on U.S. NRC waste classification criteria which considers the composition and concentration of radionuclides.

Under U.S. regulations waste conditioning for this waste stream under extended storage or permanent disposal would not require immobilization provided waste characteristics did not change.

Since low level waste disposal is not yet practised in Canada there are no regulations governing conditioning requirements.

However, even though extended storage or disposal safety analyses may indicate that ash can be safely managed without immobilization, transportation concerns may drive the regulations for conditioning to be more restrictive. It is for this reason that ash will be solidified in bitumen/13/ prior to emplacement into the AECL-CRNL IRUS (Intrusive Resistant Underground Storage) facility due to start operation in 1991. Furthermore the solidification matrix is also another containment barrier for the release of toxic materials in the ash. It is prudent therefore to develop simple solidification techniques for this waste stream even though existing regulations do not demand it.

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REFERENCES

1. Krochmalnek, L.S., Kohout, R., "Management of Combustible Radioactive Wastes in Ontario Hydro", 2nd International Conference on Radioactive Waste Management, Winnipeg, Manitoba, Sept, 1986.

2. Williamson A.S., "Radioactive Incinerator Ash Characterization", OHRD Report No: 83-207-K, May, 1983.

3. Krasznai, J.P., "The Characterization of Low Level Waste Arising From the Pickering Large Scale Fuel Channel Replacement Program", OHRD Report No: 87-30-K, April, 1987.

4. Williamson, A.S., "Low Level Radioactive Incinerable Waste Characterization", OHRD Report No: 88-22-K, February, 1988.

5. Dalziel, B.P., Krasznai, J.P., Krochmalnek, L.S., Williamson, A.S., "Ontario Hydro's Radioactive Waste Characterization Program and its Application to Waste Management", 9th Annual DOE Low Level Radioactive Waste Management Conference, Denver, Colorado, August, 1987.

6. Neilson, R.M., Colombo, P., "Waste Form Development Program Annual Progress Report", BNL 51614, Sept. 1982.

7. Le, V.T., Beamer, N.V., Buckley, L.P., "Experience with Radioactive Waste Incineration at Chalk River Nuclear Laboratories", Waste Management, Vol. 9, pp 67-72, 1989.

8. Analytic Services Section Report No: CE-88-6745-K, March, 1989.

9. Cheh, C.H., "Fate of Radionuclides in Incinerator Systems", OHRD Report No: 81-138-K, May, 1981.

10. Greening, F.R., "Characterization of C-14 Rich Deposits Formed in Nitrogen Gas Annulus Systems of 500 MW(e) Candu Reactors", Accepted for Publication in Radiochimica Acta, April, 1989.

11. Greening, F.R., Private Communication, June 15, 1989.

12. 10CFR61 Rules and Regulations. Federal Register Vol. 47, No. 248, Dec. 1982.

13. Buckley, L.P., Private Communication, June 21, 1989.

14. Weisgerber, A., Private Communication, July 12, 1989.